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Introduced Japanese burrowing cricket (Orthoptera: Gryllidae: *Velarifictorus* (*Velarifictorus*) *micado*) range continues to expand in North America

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Abstract

Japanese burrowing cricket, *Velarifictorus* (*Velarifictorus*) *micado* (Saussure, 1877), was introduced into the eastern United States in 1959 and has since increased its distributional range to include the eastern Great Plains and the northern United States. Although generally thought of as an urban species associated with human habitation, some specimens are now being captured in more remote areas, which is attributed to this species sometimes being macropterous and dispersing through flight. Public data sources such as BugGuide and iNaturalist were found to be sound, passive tools for identifying the expanding range of this species in the Americas. Collection and observation in atypical habitats suggest that potential ecological impacts may be occurring.

Key words

citizen science, crickets, geographic distribution, invasive species, singing insects

Introduction

Japanese burrowing cricket, *Velarifictorus* (*Velarifictorus*) *micado* (Saussure, 1877), is native to Asia and was first found in the United States in 1959 in the District of Columbia (Alexander and Walker 1962; Fig. 1). The source of the early introductions is not entirely clear, and it may have been introduced as discarded or escaped fishing bait, or via ornamental plants. Since that first discovery, *V. micado* became widely distributed and established in the eastern and southeastern United States (Walker 1977, Peck et al. 1992). Although additional reports and accounts of this species can be found on multiple internet-based sites, no updates on its range in the United States have been published since the previously referenced studies. Here, I present additional distributional records for this species in North America, which show that its geographic range has continued to increase both northward and westward in the United States. Although this species is generally not considered to be invasive or destructive (Center for Invasive Species and Ecosystem Health 2018), the range expansion documented here suggests it may be more invasive than previously thought. Potential ecological impacts associated with this species have not been documented but, as noted by Bowles and Bowles (2015), impacts resulting from some non-native species introductions may be complex and not easily described in tangible terms.

Generalized distribution maps previously constructed for *V. micado* and presented on public information sources, such as Encyclopedia of Life (2018), Mobugs (2018), Singing Insects of North America (2018), Songs of Insects (2018), and in field guides (Capinera et al. 2004) show an approximate distribution South of latitude 40°N and East of longitude -92°W. Based on collections I made during a National Park Service BioBlitz in southeastern Missouri in 2014, and during routine insect monitoring in Arkansas in 2017, it was clear that the range of this species extended beyond that typically presented. In addition to my own collecting data, I searched two common internet-based naturalist platforms for photographs of *V. micado* occurring outside this previously described range. They included BugGuide (https://bugguide.net/) and iNaturalist (https://www.inaturalist.org/). These crowdsourced portals aggregate photographs and collection data of insects and other arthropods found within the United States and elsewhere. The purpose of this study is to estimate the increased geographic range of Japanese burrowing cricket, *V. micado*, in the United States.

Methods

I collected specimens by hand (which I later pinned) and by using black-light traps (which I later preserved in 70% ethyl alcohol). Records from photographed specimens were taken from BugGuide.net and iNaturalist.org. Both websites include several photographs of *V. micado* that were taken at numerous locations in the United States. Another public database, iDigBio (idigbio.org), yielded only previously published records and those data are not presented here. I did not physically examine the specimens listed on BugGuide or iNaturalist, and I could not determine if specimens were deposited in museums or may no longer exist. I examined each photograph listed on those sites and compared them to published descriptions of the species (Alexander and Walker 1962, Capinera et al. 2004). The photographs unambiguously depict *V. micado*. Sex of specimens was determined where practical. While not a substitution for examination of physical specimens, photographic records are an important and valid means to learn

more about the distribution and phenology of species. Although photographs and accompanying information can be deleted or modified by the submitter at any time, archival web services, such as the WayBack Machine (archive.org/web/), maintain copies of those sites taken at multiple instances in time. Numerous other photographs of *V. micado* are posted on BugGuide and iNaturalist, but they fell well within the previously reported range and therefore are not included here. Three specimens of Japanese burrowing cricket listed on iNaturalist from Mexico (photos#8364819, #10828284, #9960828) could not be confirmed and are not addressed further here.

Collection acronyms are as follows: HTLN (National Park Service, Heartland Inventory and Monitoring Network, c/o Missouri State University, Department of Biology, Springfield, Missouri), BUG (BugGuide.net) and INAT (iNaturalist.org). Data in brackets [ ] were added by the author.

Results

I collected two specimens by hand (1 male, 1 female), and three by black-light/alcohol pan trap (2 females, 1 nymph). Numerous additional records were taken from BugGuide (2018) and iNaturalist (2018). Collection data follow. Some contributors of photos used an identifier rather than a formal name. In those instances where the collectors' names could not be determined, I have placed the collector's identifier in quotation marks.

Collection data.—**UNITED STATES: Arkansas**: **Marion Co.**, Buffalo National River, Buffalo River @ Clabber Creek, 36.127858N, -92.545530W, 13–14.vii.2017, D. E. Bowles and C. Cheri, black-light, female [macropterous] (HTLN); **Newton Co.**, Buffalo National River, Buffalo River @ Carver Access, 35.983355N, 93.038055W, 13–14.vii.2017, D. E. Bowles and C. Cheri, black-light, nymph (HTLN); **Searcy Co.**, Buffalo National River, Buffalo River @ Tyler Bend, 35.988611N, 92.767222W, 21–22.ix.2017, D. E. Bowles and C. Cheri, black-light, female (HTLN). **Missouri**: **Newton Co.**, George Washington Carver National Monument, prairie, 36.989341N, -94.357135, 27.ix.2014. D. E. Bowles, at large, 1 male, 1 female (HTLN).

Records from BugGuide and iNaturalist.—**UNITED STATES: Arkansas: Benton Co.**, Bella Vista, 21.ix.2015, female, EmilyK, photo#1153123 (BUG), same, but Centerton, 5.ix.2017, female, John Moreno, photos#1462556, 1462550 (BUG), same, but Lowell, 29.ix.2015, female, Mabel Serrano, photo#1147293 (BUG); **Montgomery Co.**, Ouachita National Forest, 34.633261N, -93.581269W, 16.x.2014, female, Michael Skvarla, photo#4308701 (INAT); **Newton Co.**, Buffalo National River, 36.037828N, -93.341024W, 8.ix.2013, female, Michael Skvarla, photos#4309265, 4309202 (INAT), same, but nr. Ponca, Buffalo National River, Steel Creek, 11.ix.2013, Michael Skvarla, photos#840796, 840794 (BUG); **Washington Co.**, Fayetteville, 18.ix.2015, male, Christ Kortis, photo#1141234 (BUG), same, but Fayetteville, 5.ix.2015, female, Layton McCullars, photo#1145100 (BUG), same, but 5.x.2015, female, Zac Jones, photo#1153873 (BUG), same, but 11.x.2015, female, "anbroshu", photo#1154284 (BUG), same, but U of A, 11.x.2015, male, L. Dave Smith, photo#1149209 (BUG), same, but 12.x.2015, female, leaddiso, photo#1154233 (BUG), same, but 8.ix.2017, female, Cody Seymour, photos#1462488, 1462487 (BUG), same, but 19.ix.2017, female, "ngbadger", photo#1462604 (BUG). **Delaware: New Castle Co.**, Bear, 29.viii.2007, female, Ted Kropiewnicki, photo#141710 (BUG), same, but 31.vii.2010, female, photos#442224, 442225 (BUG), same, but 6.x.2012, female, Ted Kropiewnicki, photos#846874, 846872 (BUG). **Illinois: Will Co.**, New Lenox, 41.490497N, -87.989875W 25.vii.2016, male, Erik Attaway, photo#1277770 (BUG), photo#3909356 (INAT). **Iowa: Dubuque Co.**, Dubuque, 11.ix.2017, female, "Maria320414", photo#1439725 (BUG). **Kansas**: **Johnson Co.**, Overland Park, 30.viii.2008, female, Andrew Williams, photo#263440 (BUG), same, but 22.viii.2015, male, "NYKZ", photos#1126696, 1126695 (BUG), same, but 19.ix.2008, female, Andrew Williams, photo#263440 (BUG), same, but 27.ix.2015, 2 females, "NYKZ", photo#1130919 (BUG); **Sedgwick Co.**, Wichita, 16.ix.2010, female, Terry Allison, photo#458181 (BUG). **Michigan**: **Wayne Co.**, Dearborn, 6.ix.2013, 2 females, 1 male, Kyle Kandilian, photo#837714 (BUG). **Missouri: Boone Co.**, 38.946228N, -92.446573W, 3.ix.2017, male, "lfelliott", photo#7773805 (INAT), same, but 38.94626N, -92.44653W, 8.x.2016, female, "lfelliott", photo#4337141 (INAT), same, but 38.94626N, -92.44653W, 19.x.2016, female, "lfelliott", photo#4449513 (INAT); **Buchanan Co.**, 39.739062N, -94.829944W, 20.x.2017, male, "chinquapin", photo# 8571138 (INAT); **Camden Co.**, Osage Beach, 38.127219N, -92.65221W, 21.viii.2017, female, "firewolfspirit", photo#7595682 (INAT); **Franklin Co.**, Pacific, 28.ix.2009, female, James C. Trager, photo#1488545 (BUG), same, but 17.ix.2009, male, James C. Trager, photo#1488544 (BUG), same, but 38.487353N, -90.801582W, 22.ix.2017, SND, "jigglytuff", photo#8038422 (INAT), same, but Shaw Nature Preserve, 38.476137N, -90.822875W, 23.ix.2017, female, "eviemae", photo#8058408 (INAT), same, but 38.443384N, -90.808629W, 3.xi.2017, male, "natric4u", photo#8668506 (INAT); **Nodaway Co.**, Maryville, 40.35448N, -94.885222W, 30.viii.2017, male, Evan Grimes, photo#7722519 (INAT); **St. Louis Co.**, St. Louis, 38.602747N, -90.254968W, 17.viii.2017, male, Alex Wild, photo#7532527 (INAT), same, but 38.45059N, -90.217275W, 20.viii.2017, female, "gcwarbler", photo#7672768 (INAT). **New Jersey: Burlington Co.**, Camp Creek Run, Marlton, 28.vii.2010, male, John R. Maxwell, photos#436070, 436069 (BUG); **Camden Co.**, Atco, 19.viii.2012, female, Yurika Alexander, photo#692452 (BUG); **Essex Co.**, Newark, 40.779999N, -74.174721W, 20.x.2017, male, "carlosm", photo#8515960 (INAT); **Morris Co.**, Madison, 40.775912N, -74.431043W, 20.ix.2015, female, "iumer", photo#2080090 (INAT). **New York: Kings Co.**, New York, 40.700821N, -73.99596W, 20.viii.2015, male, Stanton B., photo#2091504 (INAT); **Nassau Co.**, New York, 40.817325N, -73.761986W, 13.ix.2017, male, "sflee8", photo#7900218 (INAT); **New York Co.**, New York City, Central Park, 24.ix.2006, female, Marie Winn, photo#79642 (BUG), same, but 25.ix.2006, male, Marie Winn, photo#79639 (BUG), same, but 40.817982N, -73.948642W, 25.x.2017, female, "mdoom"_1eg, photo#8549726 (INAT), same, but 40.818805N, -73.948372W, 25.x.2017, male, "eshika"_1eg, photo#8549352 (INAT), same, but 40.819008N, -73.9479W, 2.ix.2017, female, J. Rigby, photo#8527361 (INAT), same, but 40.81721N, -73.949246W, 2.ix.2017, female, "anasalazar", photo#7756003 (INAT), same, but 40.818722N, -73.94671W, 13.ix.2017, male, Isabel G., photo#7905290 (INAT); **Queens Co.**, Broad Channel/Jamaica Bay Wildlife Refuge, 6.ix.2014, male, Seth Ausubel, photos#991914, 991915 (BUG), same, but Forest Park, 28.ix.2013, male, Antonio Liberta, photo#1030267 (BUG); **Richmond Co.**, Staten Island, 13.iii.2017, female, Loubara, photo#1346734 (BUG), same, but 40.508153N, -74.218004W, 8.ix.2016, female, Maya, photo#4904975 (INAT); **Tompkins Co.**, Cornell Campus, Ithaca,

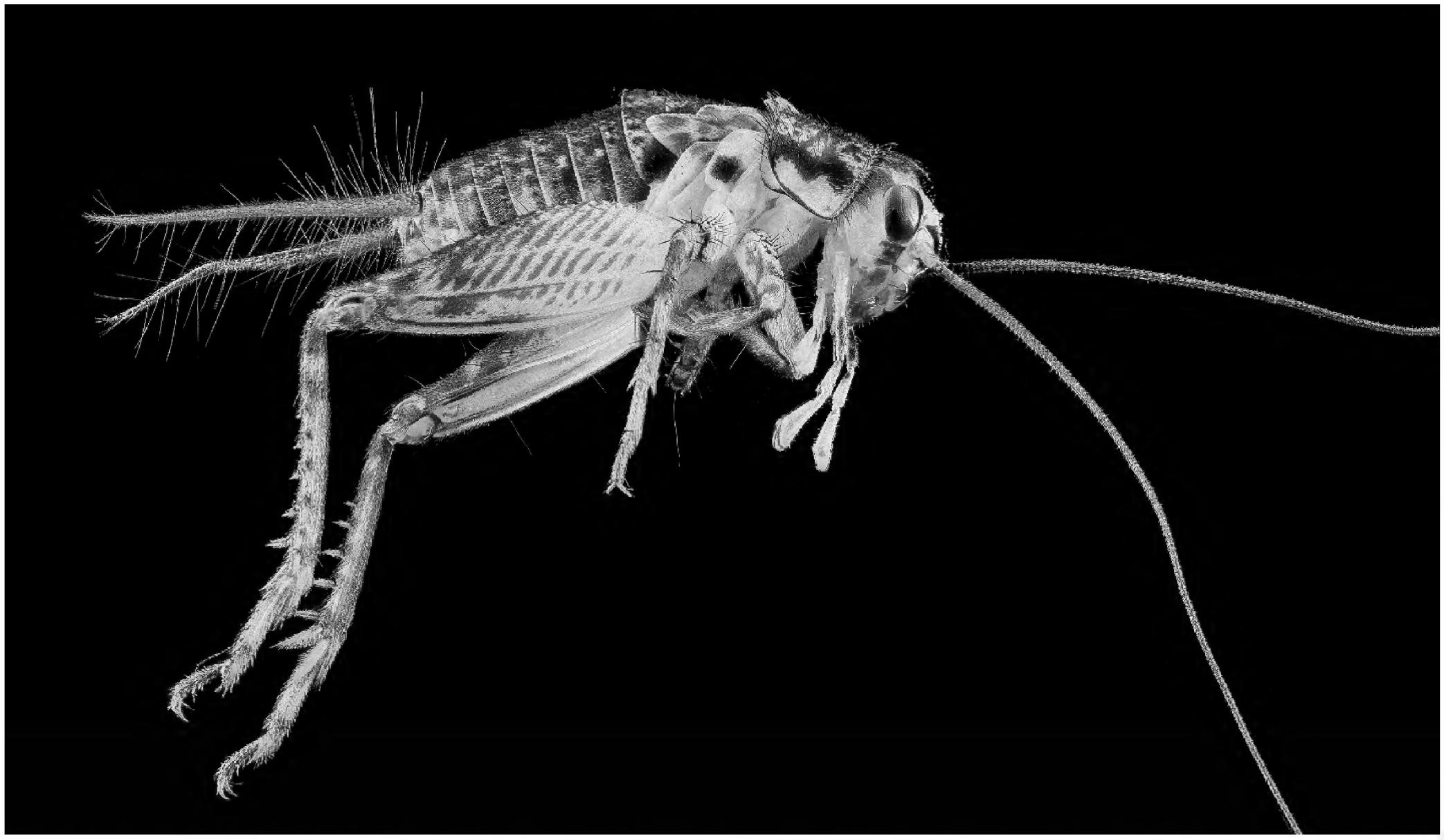

Fig. 1. *Velarifictorus* (*Velarifictorus*) *micado* (Saussure, 1877), nymph. Source: USGS Bee Inventory and Monitoring Lab, Public Domain.

27.viii.2015, 2 males, Brandon Woo, photos#1129586, 1129587, 1129588, 1129589 (BUG), same, but 5.x.2015, male, Brandon Woo, photo#1151601 (BUG), same, but 17.vii.2016, [misidentified as female] male, Brandon Woo, photo#1260224 (BUG), same, but 3.viii.2016, female, Brandon Woo, photo#1271221 (BUG), same, but male, Brandon Woo, photos#12883225, 1271221 (BUG), same, but 14.viii.2016, male, Brandon Woo, photos#12883225, 1277132 (BUG), same, but 28.viii.2016, female, Brandon Woo, photo#1286518 (BUG), same, but 27.viii.2016, female, Brandon Woo, photos#12883225, 1283223 (BUG), same, but 30.viii.2016, female, Brandon Woo, photo#1286519 (BUG), same, but 15.ix.2017, male, female, Brandon Woo, photos#1445747, 1445748 (BUG), same, but 16.ix.2016, male, Brandon Woo, photos#1293464, 1293463, 1277132 (BUG), same, but 17.ix.2015, male, Brandon Woo, photo#1141372 (BUG), same, but 42.446889N, -76.481167W, 18.ix.2015, male, Brandon Woo, photo#10074532 (INAT); **Westchester Co.**, Elmsford, 12.ix.2017, male, Preston W., photo#1439404 (BUG), same, but Bronxville, 24.ix.2010, female, Andrew V.F. Block, photo#461274 (BUG), same but 40.952106N, -73.772022W, 19.IX.2017, male, D. Ruby, photo#7996228 (BUG). **Ohio: Lucas Co.**, Toledo, 41.689971N, -83.615041W, 23.ix.2017, male, J. Witter, photo#8065789 (INAT). **Oklahoma: Okmulgee Co.**, Henryetta, 7.vii.2005, male, Charles Schurch Lewallen, photo#23583 (BUG). **Texas: Dallas Co.**, DeSoto, 23.ix.2008, female, Gacko, photo#284824 (BUG), same, but Dallas, 32.704863N, -96.852556W, 7.x.2017, female, "butterflies4fun", photo#8303510 (INAT); **Harris Co.**, Russ Pitman Park, Houston, 15.vi.2012, male, John Schneider, photo#659597 (BUG), same, but Houston, 29.760048N, -95.597783W, 9.x.2016, female, Dan Johnson, photos#4309355, 4309355, 4309355 (INAT), same, but 29.761588N, -95.605404W, 9.x.2016, SND, Dan Johnson, photos# 4309354, 4309354 (INAT), same, but 29.760773N, -95.599563W, 3.x.2016, female, Dan Johnson, photo#4265317 (INAT), same, but 29.75917N, -95.594202W, 2.x.2016, female, Dan Johnson, photos#4257670, 4257670 (INAT); **Parker Co.**, Weatherford, 13.ix.2016, female, Tzila"Z" Duenzel, photos#1291788, 1291786, 1291787 (BUG).

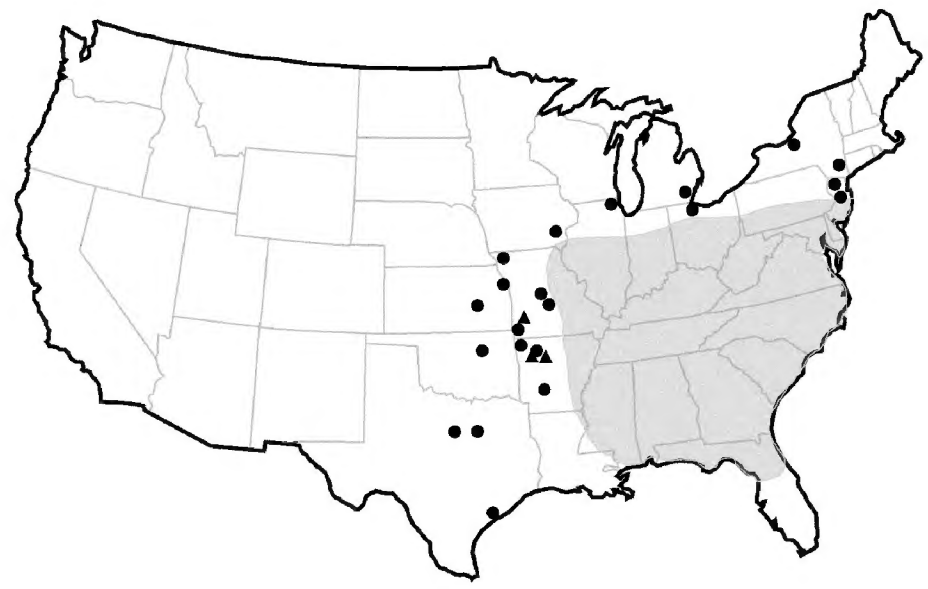

Fig. 2. Map showing the commonly projected distribution of *Velarifictorus* (*Velarifictorus*) *micado* (Saussure, 1877) in the United States of America and itscurrent known distribution. The shaded area indicates the previously reported range, triangles represent data collected by the authors, and circles represent data generated by public sources. Records are shown only for those locations that fall outside the previously reported range.

Discussion

The range of *V. micado* has broadly expanded in the United States since it was first introduced, including a western expansion of the species range into the plains of Iowa, Oklahoma, and Texas, and a northern expansion into Illinois, Michigan, New Jersey, and New York (Fig. 2). The present known range of the species in the United States now encompasses approximately 43°N, -98°W. Since *V. micado* is thought to be distributed primarily via ornamental plants (Walker 1977), it is unknown if some of the records presented here represent localized, temporary introductions, or breeding populations. Most specimens were collected/observed from June through early November, and the majority were observed during August and September. Although most of the records reported here are from cities and urban areas, several specimens were collected in rural areas, including the Buffalo National River, Arkansas, and a restored prairie at George Washington Carver National Monument in southwest Missouri. Other specimens were photographed in the Ouachita National Forest, Arkansas. Those specimens are arguably less likely to have been introduced via ornamental plants and may have dispersed there via flight. Dispersal by flight cannot be ruled out since some individuals can be macropterous. Notably, one female collected at Buffalo National River, Arkansas, was macropterous. Since this species overwinters in the egg stage, it also is possible that some breeding populations may become established in northern areas (Alexander and Walker 1962).

V. micado is now occupying ecological habitats previously unreported for the species. In the southeastern United States and throughout its native range in Asia, this species primarily inhabits mesic habitats including grassy fields and wet, wooded and partially wooded areas (Walker 1977). However, it's occurrence on the Great Plains (Fig. 1) suggests it may be adapting to drier grassland habitats. Walker (1977) suggested that inadequate soil moisture might limit the spread of *V. micado* in Florida, which may ultimately limit its spread into drier areas of the western United States.

Using public data does present some concerns. For example, Carlson et al. (2012) noted that passive surveillance tools such as BugGuide may have an inherent bias because records are added haphazardly in contrast to active, professional sampling efforts that often target specific taxa. As illustrated by this paper, however, passive surveillance is certainly preferable to the absence of sustained professional surveillance. Using internet-based tools such as BugGuide and iNaturalist can be especially useful for tracking certain species readily identified through photographs. Such sources can provide much greater coverage than one or a few individual scientists can practically accomplish (Marshall 2008, Epps et al. 2014, Michonneau and Paulay 2015, Geneviève et al. 2018). Indeed, citizen-generated distributional data or 'digital collecting' based on photographs can serve as a valuable tool to study the ranges of selected taxa, including medically important and non-native, invasive species, and species of conservation concern (Marshall 2008). Other studies have successfully used BugGuide locality data to augment professionally collected distributional data (Carlson et al. 2012, Epps et al. 2014, Bowles et al. 2015, Brunke 2016, Hoebeke et al. 2017, Wheeler 2018).

In addition to public data sources such as BugGuide and iNaturalist, BioBlitz-type events using citizen scientists can be instrumental for further defining the ranges of species by using groups of interested naturalists to collect specimens for identification by taxonomic experts (Gimmel and Ferro 2010, Plumb 2014, Wiedenmann et al. 2014, Hinsey and Johnson 2015, National Park Service 2016). BioBlitzes and rapid biological inventories, including those for invertebrates, are becoming increasingly popular. They can provide important species occurrence records when properly documented through preservation and curation, or through photographs. BioBlitz events and other citizen scientists' collections, when coupled with internet platforms such as BugGuide and iNaturalist, present potentially powerful passive surveillance tools that help provide a practical and relatively low-cost means to help "bridge the gap" between broad based biodiversity inventories and intensive biodiversity monitoring and research. Interestingly, *V. micado* has a distinctive calling song which allows for its identification in the field (Walker 1977). Training volunteers to search for this species using its call may be a way to further delineate its range.

Conclusions

The range of introduced Japanese burrowing cricket in the United States has increased beyond previously published accounts to include remote and atypical habitats. This information suggests that the Japanese burrowing cricket may be more invasive than previously thought. BioBlitzes involving citizen scientists and internet-based public data sources present passive but sound tools for documenting the occurrence and spread of easily identified species.

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